

Design of Single Point Urban Interchanges

The Missouri Department of Transportation has three functional Single Point Urban Interchanges (SPUI) but there are no specific design guidelines for them. This research was undertaken to provide design guidelines for SPUI and provide a set of warrants to decide when to install SPUI as compared to Diamond Interchanges. These guidelines will help MoDOT engineers in making engineering decisions regarding the installation of SPUI. An overpass SPUI is located in figure 1.

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In order to address the objectives of this research, a two step approach was used. First, a comprehensive literature review was conducted. The results of the literature review were used to develop a survey instrument sent out via the AASHTO Research Advisory Committee (RAC) listserve. The questionnaire consisted of 14 questions and was designed to ascertain the current state of practice in the US regarding the planning, design and construction of SPUI and to identify whether other states had any specific guidelines for the design of SPUI. Fourteen states provided responses to the survey.



Figure 1: Overpass SPUI

Source: http://www.thenewi64.org/1d1_designfeat.jsp

In this report different key geometric and operational characteristics of SPUI were studied and their influence on SPUI design discussed. Some of the most important geometric

characteristics and operational characteristics are grade separation, skew angle, roadway characteristics, signal phasing, left turn radii, right turn radii and traffic volume. Other characteristics such as cost of construction, accident studies etc are also considered important. Most of the states surveyed have different criteria for each of the design characteristics, but certain range of values were recommended as used by most of the states.

Survey results showed that most states ranked right of way as the most important reason for installing SPUI. Some of the states also ranked increase in capacity as the main reason. When there was a need for frontage roads, SPUIs were discouraged as this reduced the efficiency of SPUI. It is commonly agreed that SPUI does not accommodate pedestrian crossing effectively. A separate phasing is required for the pedestrians and this reduces the efficiency of SPUI. One of the main reasons for many states not using a SPUI is that the cost of construction is very high. Also many expressed apprehension that SPUI will cause confusion among drivers.

This study provides recommendations for the considerations in selecting a SPUI and associated key design characteristics. Although there are no specific guidelines for the installation of a SPUI, this study will hopefully make engineering judgment among MoDOT engineers more consistent. This report should be used as a reference whenever a SPUI is being considered.

Specifically, the following recommendations were made regarding the installation of SPUI:

- Whenever there is a limited right of way, SPUI are a more attractive option. SPUIs require less right of way than Diamond interchanges. There are no specific criteria for calculating the right of way for SPUI. However, it was found that SPUI usually requires right of way in the range of 200-400 feet. The right of way required by Diamond interchanges is about 30% more than that required by SPUI and usually is found to be around 270 feet.
- When the crossroad volume is between 15,000 and 30,000 AADT, SPUIs are a superior option to Diamond interchanges. SPUI are considered to have more capacity than Diamond interchanges. So SPUI are usually used in high volume conditions. When volumes are between 20,000 and 35,000 AADT for major roads, a SPUI should be used instead of a Diamond Interchange.

- When frontage roads are present, a SPUI should not be used. The presence of frontage roads increase the normal three-phase signal system to four-phase signal system and increases the delay for the overall system. The presence of frontage roads degrades the performance of SPUIs considerably and is not recommended.
- When two roads intersect at a large skew angle, construction of a SPUI is not recommended. A skew angle increases the construction cost and also reduces sight distance at the SPUIs. The skew angle should be between -30 and +28 degrees for the SPUI to be constructed. If the skew angle is greater, a SPUI should not be selected.
- It is easier to coordinate the SPUI's one signal with other signalized intersections compared to the Diamond interchange's two. Thus the SPUI is preferred when arterial coordination is required.
- SPUI construction cost is much higher than for a Diamond interchange. It costs approximately \$1 million-\$2 million more than a Diamond interchange.
- It is not desirable to provide a pedestrian crosswalk for SPUIs. Providing an additional phase for pedestrian crossing degrades the efficiency of SPUI. When pedestrian volumes are high, a pedestrian overpass should be constructed or a pedestrian crossing should be provided at the adjacent intersection or SPUI should not be selected.
- No increase in accidents was observed with SPUIs. SPUIs have an increased number of side-swipe accidents compared to Diamond interchanges, but a smaller number of angle accidents.

The report also made the following recommendations regarding key design elements at SPUI:

- Overpass SPUIs are easier to construct and, because of its simpler structural design, less destructive to adjacent property. The typical bridge span length for SPUIs is 120 feet to 200 feet and about 100 to 150 feet for Diamond interchanges.
- The number of through lanes is usually 4 or 6. Since SPUIs are mainly used for high volume conditions, fewer than 4 lanes are not usually constructed.

- The median width for the crossroad should be 4 feet if no pedestrian crossing is considered, otherwise 6 feet should be provided. Major road medians should be 18 feet wide for the underpass design and 20 feet wide for the overpass design. Medians are typically raised or flushed.
- Islands should be large, varying from 2,400 square feet to 33,000 square feet. Small islands, less than 75 square feet, should be painted and flushed due to poor visibility. The minimum dimension should be 6 feet per side and the surface area should be 81 square feet.
- Since it is difficult to modify SPUIs after construction, it is advisable to design dual left turn lanes for crossroad and off-ramp movements.
- The left turn radii for the crossroad left turns should be around 200 feet for both overpass and underpass designs while for the ramp left turns the radii should be around 210 feet. The overpass can have a greater range of radii because of the fewer physical constraints imposed by bridge structure. The left turning radii of SPUIs may range from 170 to 400 ft.
- Right turn radii should be around 100 feet for crossroad left turns and 120 feet for off ramp left turns. Right-turn radii in SPUI can range from 70 feet to 200 feet.
- The most important lighting design principles are uniformity of light and minimization of glare. Use of well-pack lighting units along the vertical walls of SPUI bridges should be discouraged. The central intersection area is the most important area of the interchange and should be well lighted.
- Overhead guide signing is recommended for crossroad approaches. Traffic guide sign applications on the exit ramps must be consistent with the mainline signing plan. At least one set of “WRONG WAY” signs should be placed on the exit ramp to protect against wrong way traffic.
- Most SPUIs use a single, actuated signal controller. A typical SPUI has a three-phase signal using a standard NEMA (National Electrical Manufacturers Association) 8-phase dual ring and traffic-actuated controller. If a frontage road is present, a 4-phase signal is provided.
- The green signal usually used in SPUI for one phase lasts around 20 seconds to 40 seconds in high volume conditions. Clearance time in SPUIs last much longer than Diamond interchanges because of the large SPUI intersection area. All-red clearance intervals for SPUIs range from 1.0 second to 10.0 seconds per phase. SPUIs usually have longer cycle lengths than most of the other interchanges. Cycle lengths vary from 80 seconds to 180 seconds for SPUIs. The average cycle length of a SPUI with frontage roads vary from 100 seconds to 150 seconds.
- For the overpass SPUI cross road signals should be placed on the side of the overpass bridge deck or should be hung to the bridge depending on the height of the overpass structure. For underpass SPUI all the signals on the cross road should be placed either using a tubular beam or span wire. In addition, proper lane markings should be provided to guide drivers to their respective receiving lanes.

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